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# THESIS



AN ANALYSIS OF THE POTENTIAL USE OF THE BARON-MYERSON MODEL BY DOD TO REGULATE SOLE SOURCE SUPPLIERS

by

David B. Bearden

March 1994

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This study attempted to determine if the Department of Defense (DOD) could use the Baron-Myerson model as a tool to regulate sole source suppliers under a price-based acquisition process. A spreadsheet was used to analyze the potential for risk reduction when choosing between a Uniform or Triangular probability distribution for use with the model. Personal and telephonic interviews were conducted with practitioners to assess whether conditions necessary for use of the model exist in the DOD procurement environment. The research indicated that, in general, there is no dominant strategy when selecting either a Triangular or Uniform distribution. However, a dominant strategy emerged when the demand level was high, the cost range was narrow and the demand curve was steep. The research further indicated that the pre-conditions for using the model potentially exist in DOD for many cases. Even so, it must be stressed that the model is not well suited for all situations and should be used selectively. This study recommends that DOD continue to explore the use of the Baron-Myerson model to further assess the impact of current legislation on the use of the model and what modifications or waivers would be needed. Finally, DOD should look into conducting a pilot program on a small scale to observe the model in practice. This would allow a low risk method to evaluate the model's potential for more widespread use.

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# An Analysis of The Potential Use of The Baron-Myerson Model By DOD To Regulate Sole Source Suppliers

by

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Submitted in partial fulfillment
of the requirements for the degree of

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## ABSTRACT

This study attempted to determine if the Department of Defense (DOD) could use the Baron-Myerson model as a tool to regulate sole source suppliers under a price-based acquisition process. A spreadsheet was used to analyze the potential for risk reduction when choosing between a Uniform or Triangular probability distribution for use with the model. Personal and telephonic interviews were conducted with practitioners to assess whether conditions necessary for use of the model exist in the DOD procurement environment. The research indicated that, in general, there is no dominant strategy when selecting either a Triangular or Uniform distribution. However, a dominant strategy emerged when the demand level was high, the cost range was narrow and the demand curve was steep. The research further indicated that the pre-conditions for using the model potentially exist in DOD for many cases. Even so, it must be stressed that the model is not well suited for all situations and should be used selectively. This study recommends that DOD continue to explore the use of the Baron-Myerson model to further assess the impact of current legislation on the use of the model and what modifications or waivers would be needed. Finally, DOD should look into conducting a pilot program on a small scale to observe the model in practice. This would allow a low risk method to evaluate the model's potential for more widespread use.

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# I. INTRODUCTION

## A. BACKGROUND

Current recommendations for acquisition reform call for the creation of a process more like that of the commercial sector by converting from a cost-based to a price-based system. This process would increase reliance on competition as a tool to regulate prices, instead of requiring extensive cost or pricing data.

Yet, the decline in defense procurement spending is causing a related decrease in the size of the defense industry base. In some cases sole source situations are being created. Given a lack of competition in these situations, how can the Government ensure that the contractor is charging a fair and reasonable price?

One particular model that shows some potential usefulness was created in 1982 by David P. Baron and Roger B. Myerson. They developed an economic model for regulating the prices set by monopolists, whose exact costs are unknown to the regulator. [Ref. 1] If this model can be adapted for use in the DOD procurement process, it may provide a valuable method of risk reduction while operating in a price-based system.

Past research has studied this model strictly in the context of using a uniform probability distribution. However, other probability distributions are feasible.

## B. OBJECTIVE

This study focuses on developing a method of comparing the use of a triangular distribution to the uniform distribution with the Baron-Myerson model. It also identifies the current trends in DOD acquisition reforms and discusses some implications of using the model in defense procurement.

## C. THE RESEARCH QUESTION

The principal research question was: Could the Baron-Myerson model be used in DOD procurement as a price regulating tool under a price-based procurement process?

Subsidiary research questions were:

1. What conditions or parameters determine the best distribution to use between the uniform or triangular distribution?

2. What conditions are necessary for best use of the model as a price regulating tool?

3. Do favorable conditions exist in DOD procurements for use of the Baron-Myerson model?

## D. SCOPE AND LIMITATIONS

The study identifies the current trends in the acquisition reform movement and recommendations being made for change to

the DOD procurement process. In particular, it focuses upon the recommended shift from a cost-based to a price-based purchasing system. It develops a method for reducing the risk involved in selecting an underlying probability distribution for the Baron-Myerson model. The study then identifies the demand conditions under which the model might best be used and discusses whether these situations exist in the DOD procurement arena. The study does not, however, attempt to outline any detailed implementation plan for DOD.

One limitation of doing research on the potential use of the model into DOD procurement was that the model is relatively unknown and not easily explained in a brief time period. This limited personal and telephonic interviews to more general questions about the demand conditions required for use of the model.

## E. RESEARCH METHODOLOGY

The study was accomplished by two primary means. The first step was to compare the model when using the uniform or triangular distribution. The Baron-Myerson model was constructed mathematically using both a uniform and a triangular distribution. A spreadsheet program was then developed to conduct comparative analysis of the model performance using both distributions. The second step was to identify if demand conditions exist in DOD purchasing that might allow use of the model as a price regulating tool. This

step focused around determining if cases existed where the DOD demand was not totally inflexible. Personal and telephonic interviews were conducted to question practitioners in this area.

## F. ORGANIZATION OF THE STUDY

Chapter II presents as background the impetus behind current recommendations for acquisition reform. It discusses how the reliance upon competition as a price regulating mechanism may be restricted by the downsizing of the defense industry base.

Chapter III introduces the origins of the Baron-Myerson model and explains its use with both the uniform and triangular distribution. It concludes with a risk analysis of the buyer's choice of probability distributions.

Chapter IV discusses the conditions for best use of the model. It then examines whether or not these conditions exist in DOD procurement.

Chapter V presents conclusions and recommendations of the study along with areas that might merit further research.

# II. BACKGROUND

## A. INTRODUCTION AND CHAPTER OVERVIEW

The amount of money available for U.S. defense procurement spending has declined sharply since the mid 1980's. Necessarily, the inefficiency that has existed as an integral part of the Department Of Defense acquisition process can no longer be tolerated. One recommended solution is the adoption of more commercial practices in Government purchasing. More specifically, the Government needs to shift away from a cost-based to a price-based process.

This proposed shift creates uneasiness for many because it would neutralize many of the statutes and policies currently used to maintain the public trust. More unsettling, the use of competition may not be available in all cases due to the decreasing number of suppliers in many areas of the defense market. How, then, can the Government make this change and still protect the interests of the taxpayers?

In 1982 David P. Baron and Roger Myerson developed a model for regulating a monopolist whose costs are unknown to the regulator. Selective use of this model by the Department of Defense may assist in carrying out some of these acquisition process reforms. To better understand how the model might be of use, it is necessary to consider the current

acquisition process, the forces prompting its change, and the overriding need to maintain the public trust under a new system.

This chapter provides initial background discussion of the need for acquisition process reform. It identifies problems with the present cost-based pricing system and addresses how forces in the defense economy encourage sole source situations. Finally, it explains how relying on competition for price control can create a dilemma for buyers in the current defense economic environment.

## B. ACQUISITION PROCESS REFORM

### 1. System Inefficiency

It is commonly acknowledged that the defense acquisition process in the United States has become slow and inefficient. Layers of oversight, checks and balances, and segmentations of responsibility have intentionally been built into the system to prevent any one person or group from gaining too much authority or power over any aspect of the process.

The regulatory and statutory policies in place in the system are also detrimental to efficiency. In the words of the Deputy Undersecretary of Defense for Acquisition Reform, Colleen Preston:

> ...a myriad of laws and regulations were adopted over time--for laudable reasons--in an effort to address every

possible contingency that might arise, to protect the Government's interests, to ensure the Government acquisition process is fair, as a check on the Government's authority and demands on its suppliers, or to further a social objective. [Ref. 2]

### 2. New Challenges

In the past, this process inefficiency was accepted as the price paid to maintain the public trust. Nonetheless, by 1997 the defense budget will have declined by 41 percent compared to its high in the 1980's. By fiscal year 1998, it will have fallen to three percent of GNP as opposed to the mid-1980's figure of six percent. [Ref. 2] Most of these budget cuts, 60 to 65 percent, will be in procurement. [Ref. 3]

Other challenges exist aside from the budget cuts. The defense industry base is shrinking and the world markets are becoming more competitive. Technology is evolving faster; and the commercial markets are increasingly driving state-of-the art technologies. If the United States expects to maintain a technologically superior force, it must find ways to keep its industries efficient and competitive, effectively integrate commercial and defense industries, and reduce the acquisition cycle time for procuring new weapon systems.

The aggregate effect of these developments and challenges is such that Ms. Preston says,

> The world in which DOD now must operate has changed beyond the limits of the existing acquisition system's ability to

adjust or evolve. It is not enough to improve the existing system, we need a fundamental rethinking and reinvention of the acquisition system if we are to be able to respond to the demands of the next decade. [Ref. 2]

### 3. Commitment To Change

Changes occurring until now have been incremental in nature. Simultaneous calls for reform from members of the current administration, Congress, and prominent advisory groups signal that momentum exists for more revolutionary changes.

The Executive Branch is certainly backing reforms. In September of 1993, Vice President Gore unveiled his plan for streamlining Government and cutting costs. The following month President Clinton endorsed a U.S. Senate plan to reform acquisition.

Congress is also showing its desire for reform. Many legislators from both sides of Congress are introducing bills to eliminate or modify existing acquisition laws. These bills currently include: S.1587, The Federal Acquisition Streamlining Act of 1993, H.R. 2238, H.R. 3400, and H.R. 3586. [Ref. 4]

However, the largest sources of recommendations for change in the last year have been the DOD Advisory Panel on Streamlining and Codifying Acquisition Law, or "800 Panel", and the Defense Science Board (DSB).

The Congressionally ordered Section 800 Panel review focused on identifying where changes to acquisition laws were needed. The study by the Defense Science Board Task Force On Acquisition Reform was commissioned by the Undersecretary of Defense (Acquisition) and examined a more comprehensive range of areas. Although the origin of these two bodies was different, they reached many of the same conclusions.

## C. CHANGING THE COST-BASED SYSTEM

Both the Section 800 Panel and the DSB strongly agreed that the Government must adopt a more commercial approach to acquisition. Specifically, the two groups stated the need to shift from a cost-based to a price-based system.

Speaking of the current cost-based system, the Section 800 Panel wrote that,

> One of the most expensive and disruptive requirements involves mandatory adherence to cost principles and accounting standards enumerated in statute, in the Federal Acquisition Regulation (FAR), and by the Cost Accounting Standards Board (CASB). [Ref. 5]

The DSB was even more exact in its criticism of the current system stating that, "The most important single intrusive element of the current process is the cost-based contracting system." [Ref. 6] The report lists many of the problems triggered by this process:

- Imposition of an array of unique reporting and oversight
- systems which are incompatible with commercially competitive enterprises.
- The requirement to provide and certify cost or pricing data.
- Unique cost accounting systems. [Ref. 6]

### 1. Truth In Negotiations and Cost Accounting Standards

Much of the inefficiencies and resulting costs borne by Industry and Government come from requirements of the Truth In Negotiations Act (TINA) and extensive cost accounting standards (CAS).

TINA, or Public Law 87-653, currently requires that contractors must provide certified cost and pricing data for all negotiated contracts in excess of $500,000 dollars and for those under $500,000 deemed necessary by the contracting officer. TINA provides that the requirement for obtaining certified cost or pricing data in support of a proposed price need not be applied to contracts or subcontracts where the price negotiated is based on adequate price competition or established catalog or market prices of commercial items sold in substantial quantities to the general public.

Industry leaders realized quickly that TINA was inefficient and protested that the cost of complying with its requirements were excessive. At a symposium held in 1968 to discuss the effects of TINA, one industry representative pointed out:

> ...a general increase in the administrative overhead of both primes and subs is essential if we are to accomplish all of the tasks that we are asked to perform under Public Law 87-653. We are having to spend more man hours, hire more people, and develop new systems for collecting data and laying an audit trail. All of these activities imply a much heavier administrative burden and increased costs in doing Government business. This is obviously a step in the wrong direction. [Ref. 7]

### 2. Costs Of TINA And CAS

#### *a. Higher Administration Costs*

The predictions of higher costs under TINA have come true, as evidenced by several recent studies. For example, the Office of Technology Assessment reports studies showing that the entire regulatory regime adds 10 to 50 percent to the cost of doing business with the Government. [Ref. 8] A 1992 Defense Systems Management College (DSMC) had reported costs associated with Government sales were roughly four times those associated with those to commercial customers. The DSMC data further showed that for every employee in a comparable position in a commercial division of the company, the Government division employed: eight people in accounting; six in purchasing and subcontracting; 12 in auditing, and two in legal department. [Ref. 6]

A Center for Strategic and International Studies (CSIS) Survey of companies indicated that there was a pattern to suggest commercial business spends five to ten percent of sales on administrative costs compared to 20 to 30 percent for

their defense segments. Another CSIS study reported that a major corporation's defense division had 10,000 more staff than its commercial division to administer half the business volume - the cost of the added employees alone was $750 million. [Ref. 6]

*b. Barrier To Commercial Vendors And New Technology*

The Section 800 Panel was repeatedly told that companies that sell primarily to the commercial market do not have the accounting systems that will permit them to provide the detailed cost or pricing data required by TINA. Cases of commercial companies refusing to do business with DOD due to the costs are common. One case illustrates the problem:

> A large company was planning to introduce a radio with special encryption features sought by DOD and law enforcement agencies. The item had not yet been sold in substantial quantities to the public. Because of complicated laws and regulations governing the non-competitive acquisition of new commercial products and technologies that haven't been sold in substantial quantities to the public, Federal Government buyers were reluctant to purchase the product without requiring cost and pricing data. The company would not sell the item to the Government if it had to generate and provide cost and pricing data to support the price it is charging, which it did not do to establish the commercial price. Thus, the Government continued to buy a less advanced old technology system, while commercial customers bought state-of-the-art. [Ref. 9]

*c. Loss of Current Defense Contractors*

Many companies that have already been selling to the Government are leaving the defense arena. A 1990 workshop at DSMC on "Why Firms are Leaving the Defense Market"

identified reasons why firms left or were planning to end business relations with the DOD. Among them were:

- audit procedures inconsistent with those typically used by industry
- excessive costs of doing business with DOD
- proliferation of regulations
- unnecessary calls for cost or pricing data [Ref. 10]

As Ms. Preston concludes:

> The combined net effect of these laws, regulations, and practices is a system which: adds unnecessary costs to the products of defense contractors, making it harder for them to be competitive in the commercial marketplace, prevents the Government from acquiring products from commercial contractors unwilling to change their practices to accommodate rules unique to Government contractors, and adds to DOD's cost of doing business--its 'management and control' costs. [Ref. 2]

Ms. Preston's Strategic Plan For Acquisition Reform asserts that the DOD must "transition from a cost-based to a price-based system." [Ref. 2]

### 3. Suggestions For Change

Transitioning from cost-based to a price-based system increases the risk to the Government. Making the change will require the use of mechanisms other than CAS and TINA to maintain the public trust. Both the Section 800 Panel and the DSB have recommended actions necessary to make this change. The Section 800 Panel believes that,

> By far, the largest portion of commercial items acquisitions will be able to be conducted through competition as defined in 10 U.S.C. Subsections 2302 and 2304 and in section four of the Office of Federal Procurement Policy Act (41 U.S.C. Subsection 403(6) or on the basis of established catalog or market prices as defined in the FAR(FAR 15.804-3(c)). [Ref. 5]

The DSB also recognizes the need to protect the public interest under any changes and seems confident that is possible. It does not see a change from the present system as a large risk since it contends that,

> ...the public protection offered by the current system is not a very high standard. It encourages the supplier to increase the cost of goods because that is one of the few ways available to increase profit over the long run. It discourages a supplier from investing in more efficient production processes. It creates an immense regime of contention between the Government and its suppliers around which large numbers of Government auditors, accountants, and other overseers scrimmage with an equally large number of supplier personnel. The result is a constant flow of charges and counter charges about false claims, unallowable costs, pricing deficiencies, and a host of other opportunities for differences which we believe can safely be avoided. It is very clear that the effect of this is not public trust. [Ref. 6]

They go on to say,

> We believe that even after monitoring cost is removed as a contractual entitlement, there remain several strong and effective tools available to the Government. [Ref. 6]

Some of the tools listed by the DSB include using:

- a formal, collective and accountable judgment of fair price using market surveys of similar products;

- the general regulatory environment governing the conduct of commercial business, including commercial accounting and audit practices;
- continued emphasis on the broad use of competition. [Ref. 6]

## D. MAINTAINING THE PUBLIC TRUST: A DILEMMA

Unfortunately, the very timing of the proposed acquisition reforms may actually restrict the use of competition as a technique for price regulation. The decrease in defense procurement spending in the United States is promoting a corresponding decrease in the defense industrial base. Thus, at precisely the time DOD is trying to foster more competition, the number of its suppliers is decreasing. In some supplier categories, there may only be one source left. The dilemma for the Government then becomes whether or not to maintain more than one supplier for an item or service.

This section discusses trends in the defense economy leading to sole source situations. It then addresses the propensity to encourage competition even when it is less efficient than a sole source situation.

### 1. Towards Sole Sourcing

Competition may not always be the most efficient method by which to execute a contract. Indeed, it can be impossible to have competition under some circumstances.

### *a. Destructive Competition*

In some industries a phenomena known as destructive competition may exist. This condition is characterized by a large amount of overcapacity that cannot be quickly downsized, coupled with a sharp and prolonged decrease in demand. [Ref. 11] If demand remains low for an extended period, all but the low cost producer will eventually leave the market.

The conditions described above closely resemble the current DOD procurement environment. Many of these industries are highly capitalized, and not quickly converted to other uses. The rapid decrease in Government demand for these products drives unit costs up as overhead burden is spread over the smaller product base. This combination is reducing the number of items DOD procures annually and forcing many contractors out of business. Often, only one source remains in a sector.

### *b. Proprietary Technology*

Another factor creating sole source situations is the rapid change in technology. As new innovations are made, companies retain patents giving them sole proprietorship of a product or process. In these cases, it is impossible to create a second source without expensive licensing or purchasing of data rights.

### 2. Resistance To Sole Sourcing

The Competition In Contracting Act (CICA), or Public Law 89-369, is a major deterrent to sole source contracts. CICA mandates that Government agencies will carry out all procurements under *full and open competition*[1].

Competition may not be appropriate for all situations, however, and may bring with it certain undesirable inefficiencies. As one writer puts it:

> The strong policy expressed in CICA seems to assume that some benefit (e.g., cost savings, innovation) will follow competition in every case, even when extreme measures are needed to increase the number of competitors. ...There is concern that the statute encourages competition for competition's sake, regardless of other effects. [Ref. 12]

The policy of full and open competition is "applied with vigor, even when pragmatic assessments indicate that competition will not be cost effective." [Ref. 12] Sometimes two suppliers are each given a part of the total purchase to maintain two competitive sources. This can be very inefficient. A handbook for program managers states that:

> ...if the system developer possesses excess capacity, splitting the production run may increase costs through increased overhead per unit. [Ref. 13]

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[1] CICA allows agencies to conduct procurement using other than full and open competition only under certain circumstances. The FAR Subpart 6.3 states these in detail.

Other inefficiencies may result including: production of economically inefficient quantities, higher contract administration costs, quality differences, configuration management difficulties, and technical or proprietary data rights problems.

### 3. Solving The Dilemma

The intent to use competition for price regulation will work in most procurements because an adequate number of suppliers are available to compete. However, where competition is impossible or impractical, there still remains a problem.

As mentioned earlier, The Baron-Myerson model may offer an alternative. Under the correct conditions, the model may help DOD maintain the public trust when competition is not feasible.

The following chapter will discuss the underlying principles of the Baron-Myerson model and the history of its development. However, the reader must be reminded that what follows is not a detailed implementation plan for use of the Baron-Myerson model by DOD.

# III. THE BARON-MYERSON MODEL

## A. INTRODUCTION

Baron and Myerson developed an economic model for regulating prices set by monopolists whose exact costs are unknown to the regulator. The objective of the regulator using the Baron-Myerson model is to maximize social welfare, or total surplus, of the transaction as a weighted function of consumer surplus and producer's profit. [Ref. 1]

The model assumes the condition that the producer does not share his known opportunity cost information with the regulator. At the same time, the Government cannot find out information about the producer's opportunity costs. This assumption of information asymmetry may be appropriate for many defense contractors; where opportunity costs of production are hardly known to the Government even after the production is over.

Within the Baron-Myerson framework, one can maximize the expected Government gain while inducing the contractor to reveal his true costs. Here, Government gain is the amount of consumer surplus the Government retains when purchasing a quantity of items.

This chapter explains the origin and underlying principles of the model. It shows the application of the model using the

uniform distribution. It then applies the triangular distribution to the model. Finally, it concludes with analysis to determine what factors might influence the choice of the distribution when the regulator cannot, *a priori*, decide the appropriate form of the distribution.

## B. ORIGIN OF THE MODEL

While Baron and Myerson's model is uniquely their own, its *de facto* truth revelation strategy may be traced back to earlier literature. To better understand the Baron-Myerson model, it is helpful to discuss the evolution of its underlying principles.

### 1. Naive Approach

Consider the situation where the producer is a monopolist. Assume the Government cannot verify the producer's costs, but treats the producer's cost report as genuine and bases its purchasing decision on the report.

This characterization may not be too far off from many defense procurement situations where there is little competition and it is difficult for the Government to find the producer's true opportunity costs. This situation may become more realistic as the defense budget declines and fewer resources are allocated in cost estimation and verification efforts. Contraction of the defense industrial base also lessens competition and contributes to this problem. The lack of detailed cost or pricing data and reduced competition

leaves the Government more vulnerable to potential price gouging by the producer.

Under this naive approach, the Government uses the firm's reported price and its own demand curve to determine the quantity *(Q)* it will buy. Under these circumstances, the monopolist will report a price $(R_M)$ that will maximize his total profits. Thus, if the producer assumes the Government demand curve is linear and written:

$$Q = a - bP$$

where a and b are parameters of the demand function and P as the price, then the monopolist's profit $(\Pi_M)$ is represented as:

$$\Pi_M = QR_M - QC$$

where $C$ is the actual constant marginal cost.

By differentiating the profit function with respect to $R_M$ and setting it equal to zero, the profit maximizing level of $R_M$ is found as:

$$R_M = \frac{(a+bC)}{2b}$$

which is always greater than the true cost $C$.[2] The level of Government purchase, accordingly, becomes smaller and is given as:

$$Q_M = \frac{(a+bC)}{2}$$

The producer's profit $\Pi_M$ may be expressed as:

$$\Pi_M = Q_M(R_M - C)$$

$$\Pi_M = \frac{(a-bC)^2}{4b}$$

The Government's gain for this case is computed as $GG_M$:

$$GG_M = .5\left(\frac{A}{B} - R_M\right)Q_M$$

$$GG_M = \frac{(a-bC)^2}{8b}$$

From the Government's point of view, the naive approach is undesirable. It implies that the monopolistic producer will try to set its prices at a profit maximizing level, which might be much higher than prices set under competitive market conditions. Thus, the Government could pay a higher cost, afford fewer items, and receive less consumer surplus, or Government gain.

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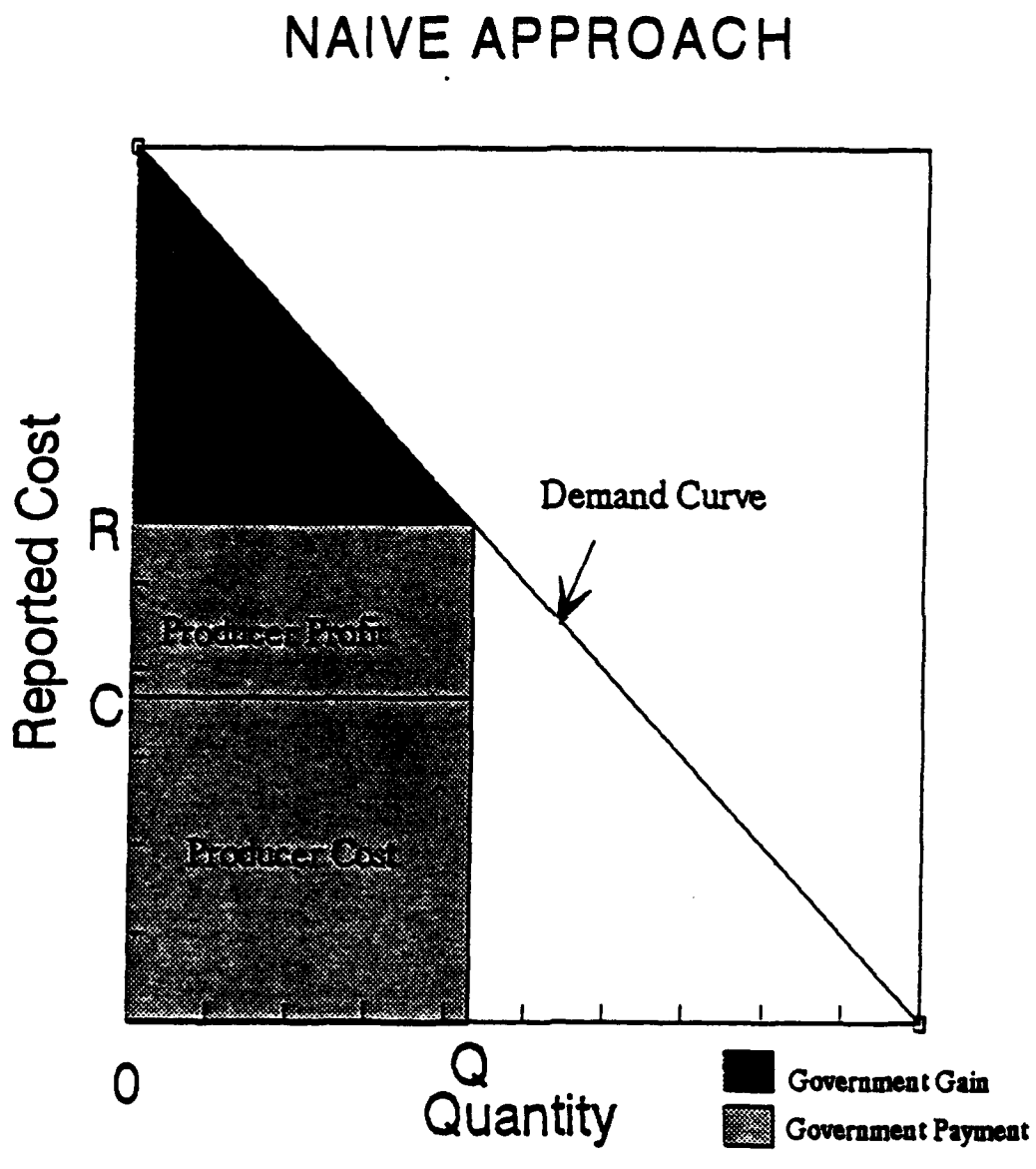
[2]Note that the vertical intercept of the demand (a/b) must be greater than the cost c to have a positive level of output Q.

Figure 3-1


NAIVE APPROACH
Reported Cost
R
C
0
Q
Quantity
Demand Curve
Producer Profit
Producer Cost
Government Gain
Government Payment

## 2. Loeb-Magat

In 1979 Loeb and Magat developed a strategy to encourage the monopolist to reveal his true cost to the regulator. Their truth-revealing strategy was for the regulator to pay the producer all of the consumer surplus in addition to the producer's reported costs. [Ref. 14] Since all the gains from production are transferred to the producer, the producer has no incentive to falsify the costs or to be inefficient in its production. Figure 3-2 illustrates the Loeb-Magat model.

Figure 3-3a. shows the reduction in profit (the shaded triangle, area abc) when the producer reports his cost as $R_H$, higher than his actual cost $C$. Figure 3-3b. shows the reduction in profit (the shaded triangle, area def) when the producer reports his costs as $R_L$, lower than his actual cost. Thus, the profit maximizing strategy for the producer under Loeb-Magat is to report his costs truthfully.

The price to the Government of obtaining this cost information is very high because the Loeb-Magat mechanism gives away all of the consumer surplus to the producer. In this case, the total cost to the Government would exceed the cost under the naive approach. Thus, while it would know the true cost of the items purchased, the Government is not likely to be interested in this mechanism.

Figure 3–2
LOEB–MAGAT

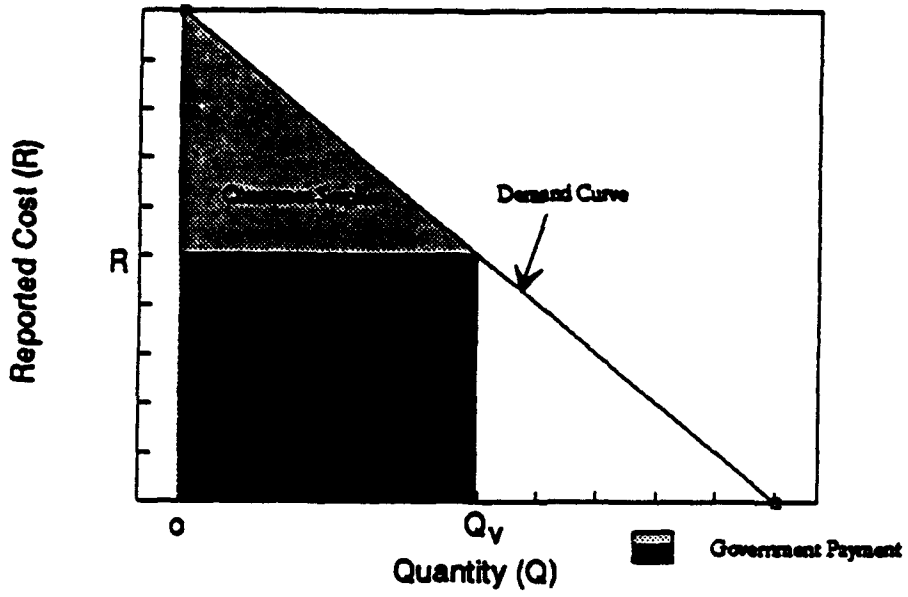



Figure 3–3a.
LOEB–MAGAT

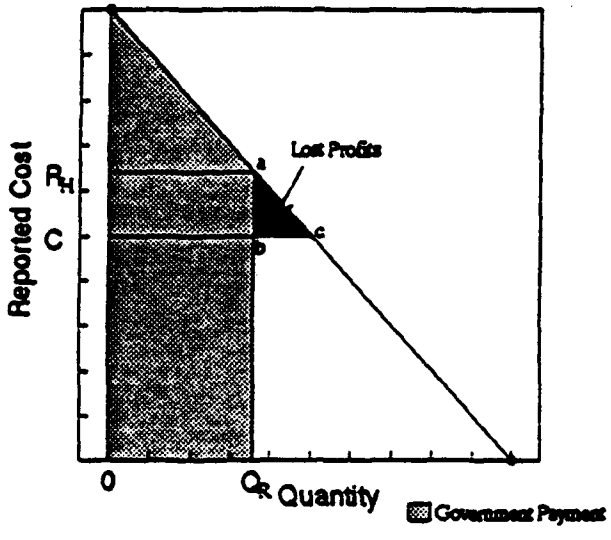
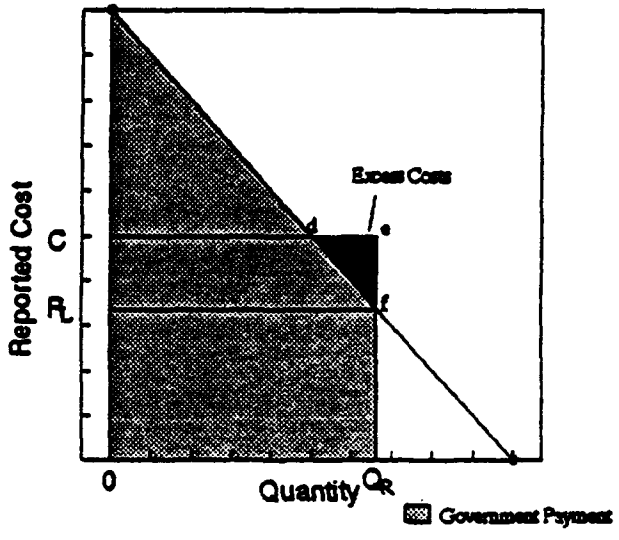



Figure 3–3b.
LOEB–MAGAT



## C. PRINCIPLES OF BARON-MYERSON

Like the Loeb-Magat model, the Baron-Myerson model induces the producer to reveal his true cost. But, the Baron-Myerson model can maximize the gain to the Government. It achieves this by providing the producer a special payment structure that results in a more elastic effective demand. It then provides the producer all of the consumer surplus under this more elastic effective demand. The degree of elasticity is based on the Government's probability belief of the likely costs to the producer.

### 1. Uniform Distribution

When the Government cannot estimate the likely unit cost for the producer, it may resort to using a uniform probability distribution. The use of a uniform distribution implies that the Government feels that any cost is equally likely. In fact, much of the Baron-Myerson illustration has been based on the use of a uniform probability distribution. The Government chooses the lower and upper cost values $(L, U)$ based upon its best estimate. If the unit cost for $C$ is uniformly distributed, then the pdf for $C$, $f(C)$ is given by:

$$f(C) = \frac{1}{U - L}$$

then the cumulative distribution for $C$, $F(C)$, is given as:

$$F(C) = \int_L^C \frac{1}{U-L} dC$$

$$F(C) = \frac{C-L}{U-L}$$

When the producer reports his cost as $R$, the Government will pay him a unit payment, $v(R)$, larger than $R$ and purchase the amount $Q[v(R)]$. The level of this *excess* payment that maximizes the Government's gain, in turn, is affected by the probability belief on $C$. In general, v(R) is written as:

$$v(R) = R + \frac{F(c)}{f(c)}$$

With a uniform distribution, the unit payment is:

$$v(R) = 2R-L$$

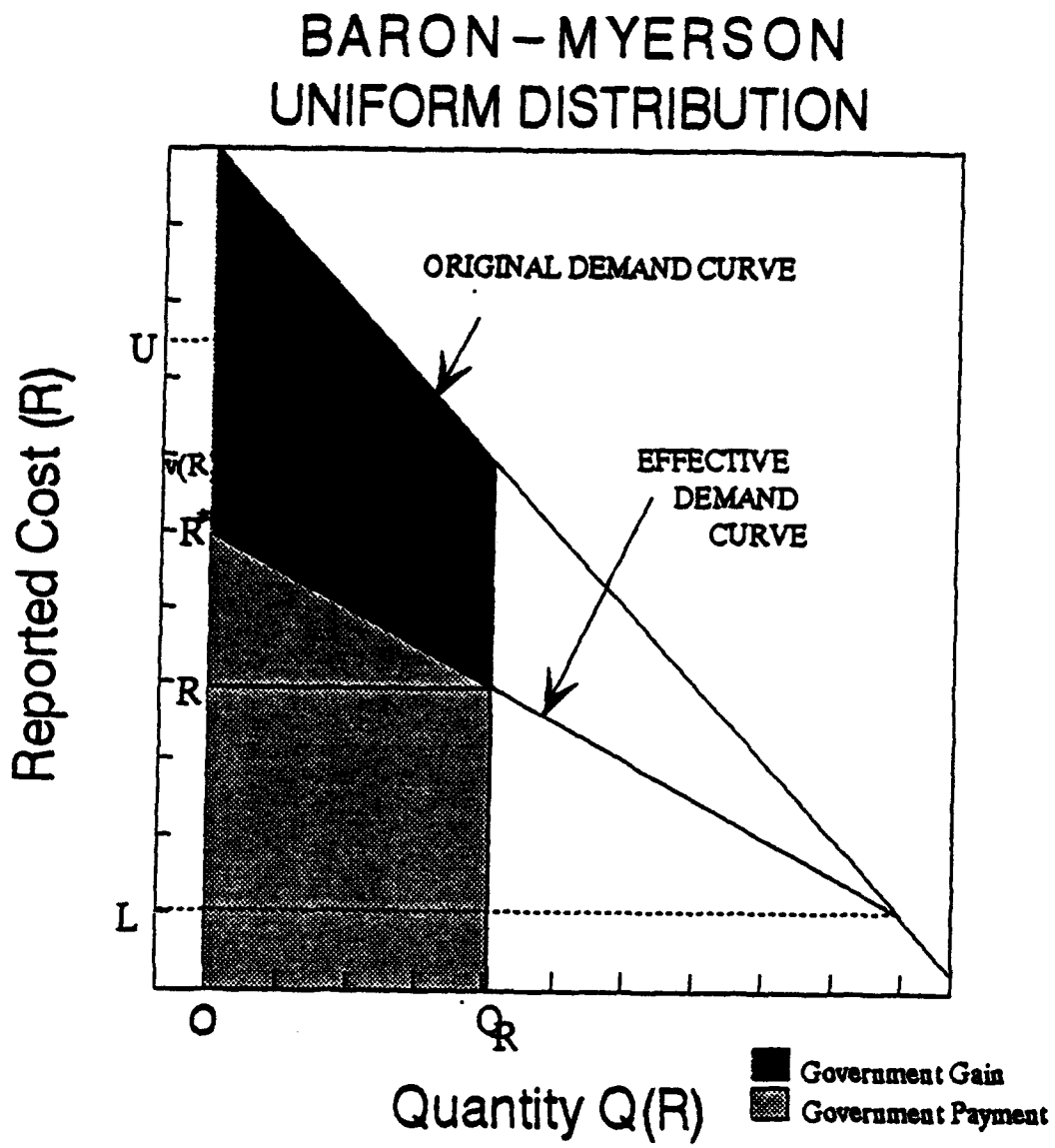
The quantity the Government purchases is given by:

$$Q(v) = a-b[v(R)]^3$$

---

[3] Substituting the unit payment expression v(R) into this equation gives a more elastic modified demand curve Q(R) as follows: $Q(R) = (a+bL) - 2(bR)$.

Figure 3-4


BARON – MYERSON
UNIFORM DISTRIBUTION
ORIGINAL DEMAND CURVE
EFFECTIVE
DEMAND
CURVE
U
v(R)
R*
R
L
O
$Q_R$
Reported Cost (R)
Quantity Q(R)
Government Gain
Government Payment

To induce the truth-telling on the part of the producer, the Government adjusts its initial payment, $v(R) \cdot Q[v(R)]$, by adding the amount $A(R)$, where $A(R)$ can either be positive or negative depending on the value of R and is written as:

$$A(R) = \int_R^{R^*} Q[v(r)]\,dr - Q[v(R)]\,[v(R) - R]$$

This adjustment is made so that the government's *net payment* to the contractor becomes just equal to the entire area under this more elastic demand curve for the quantity up to $Q[v(R)]$. In this way, the Baron-Myerson model makes use of the Loeb-Magat idea of paying full surplus to the producer, but based on the "modified" rather than the actual demand. This use of a more elastic demand instead of actual demand for the payment provides the source of the Government gain. The Government payment $GP$ to the contractor under the uniform distribution is given as:

$$GP = \int_0^{Q(v)} \frac{A+BL-q}{2B}\,dq$$

$$GP = \frac{AQ(v)}{2B} + \frac{LQ(v)}{2} - \frac{Q(v)^2}{4B}$$

The Government gain is then the area between the actual demand and the modified demand curve and is given as:

$$GG = \int_0^{Q(v)} \left\{ \frac{A-q}{B}\,dQ(v) - \frac{A+BL-q)}{2B} \right\} dq$$

Since both the original and modified demand curves are linear across their entire range, the values for *GP* and *GG* can also be found geometrically.

There are situations for which other distribution forms may be more appropriate. The next section explores the use of the triangular distribution. In particular, it discusses what form of distribution would maximize the Government's expected gain when one is not sure which distribution is indeed true.

**2. Triangular Distribution**

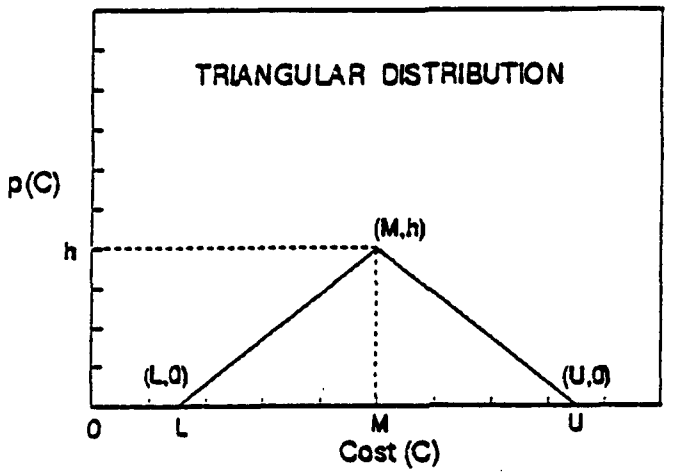
The use of a uniform distribution is generally appropriate when the Government's knowledge of costs is very limited. However, as the Government gains more cost information, it may want to use other distribution forms. Instead of merely choosing an upper and lower value for the possible cost range, it can select a most likely cost value to form a triangular distribution.

If $C$ has a triangular pdf, then its distribution parameters are given by $(L,M,U)$, where $L$ is the value at the lower endpoint, $(L,0)$, $M$ is the most-likely value corresponding to the apex point $(M,h)$, and $U$ is the upper value at the endpoint, $(U,0)$. See Figure 3-5.

Since this is a pdf function, the height $h$, of the apex can be expressed as:

$$h = \frac{2}{(U-L)}$$

Figure 3-5




The slope, $m$, of the pdf function is given by:

$$m_1 = \frac{2}{(M-L)\,(U-L)} \qquad \text{for } L \le C \le M$$

$$m_2 = -\frac{2}{(U-L)\,(U-M)} \qquad \text{for } M \le C \le U$$

The pdf for $C$, $f(C)$, is given by:

$$f(C) = \begin{cases} m_1 (C-L) = \dfrac{2(C-L)}{(M-L)\,(U-L)} & \text{for } L \le C \le M \\ m_2 (C-L) = \dfrac{2(U-C)}{(U-M)\,(U-L)} & \text{for } M \le C \le U \end{cases}$$

The cdf for $C$, $F(C)$, is then:

$$F(C) = \begin{cases} \int_L^C \frac{2(t-L)}{(M-L)(U-L)}\,dt = \frac{(C-L)^2}{(M-L)(U-L)} & \text{for } L \le C \le M \\ \frac{(M-L)}{(U-L)} + \int_M^C \frac{2(U-t)}{(U-M)(U-L)}\,dt = 1 - \frac{(U-C)^2}{(U-M)(U-L)} & \text{for } M \le C \le U \end{cases}$$

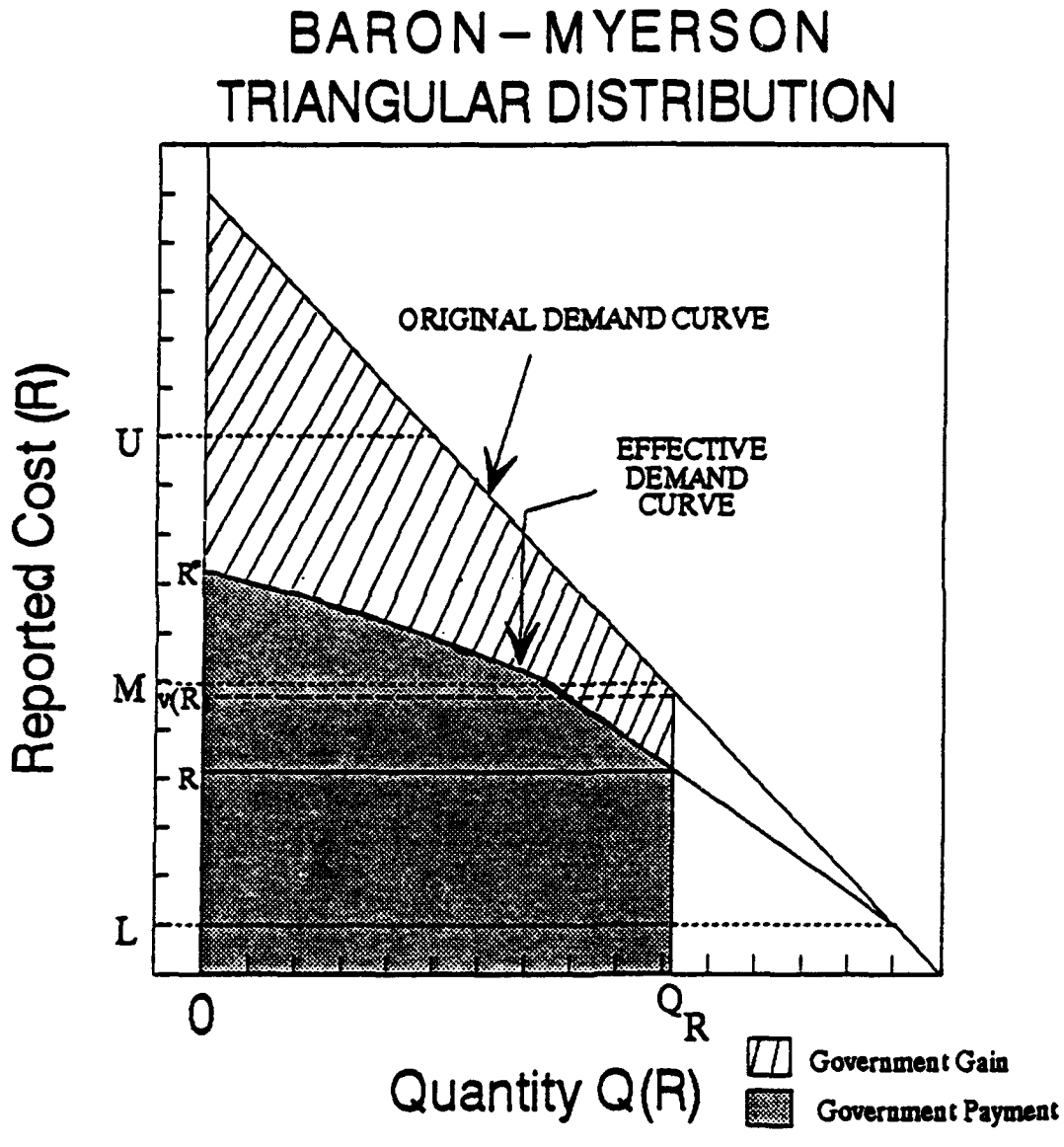
The unit payment, $v(R)$, to the contractor, is given as:

$$v(R) = \begin{cases} 1.5R - 0.5L & \text{for } L \le R \le M \\ R + \frac{(U-L)(U-M) - (U-R)^2}{2(U-R)} & \text{for } M \le R \le U \end{cases}$$

Just as with the uniform distribution, the Government modifies its demand curve to recapture some consumer surplus as Government gain. If the original demand curve is $Q = a - bP$ then substituting $v(R)$ for $P$ in the equation gives:

$$Q(V) = \begin{cases} (a + 0.5bL) - 1.5bR & \text{for } L \le R \le M \\ 3BR^2 - (2A + 4BU)R + 2AU + BLU + BMU - BLM & \text{for } M \le R \le U \end{cases}$$

Figure 3-6


BARON – MYERSON
TRIANGULAR DISTRIBUTION
ORIGINAL DEMAND CURVE
EFFECTIVE DEMAND CURVE
Reported Cost (R)
U
M
L
R'
w(R)
R
0
$Q_R$
Quantity Q(R)
Government Gain
Government Payment

The modified demand is linear in $R$ for $L<=R<=M$, and becomes strictly concave for $M<=R<=U$.[4] The vertical intercept, $R^*$, for the modified demand curve is found using the quadratic equation:

$$R^* = \frac{(2A+4BU) \pm \sqrt{(2A+4BU) - 4(3B)K_1}}{6B}$$

where $K_1 = (2aU+bLU+bMU-bLM)$.

The Government's payment, $GP$, then becomes:

$$GP = \int_0^{Q(v)} R(q)\, dq$$

As with the uniform distribution case, the Government gain $GG$ is found by subtracting the Government payment from the area under the original demand curve when the curve is integrated from zero to $Q(v)$:

$$GG = \int_0^{Q(v)} \left( \frac{a-q}{b} - R(q) \right) dq$$

---

[4] The inverse demand function $R(Q)$ is given by:

$$R(q) = \begin{cases} \left(\frac{a+0.5bl}{1.5b}\right) - \frac{q}{1.5b} & \text{for } Q_M \leq q \leq Q_L \\ (2a+4bU-2q) - \frac{\sqrt{(2a+4bU-2q)^2 - 12bK}}{6b} & \text{for } 0 \leq q \leq Q_M \end{cases}$$

where $Q_M$ and $Q_L$ correspond to the quantity purchased when $R=M$ and $R=L$ respectively. K denotes the value, $K = (2aU+bLU+bMU-bLM) - 2Uq$.

## D. TRIANGULAR AND UNIFORM DISTRIBUTION RISK ANALYSIS

Suppose the underlying cost distribution could either be uniform or triangular. Depending upon the Government's expertise in prediction, there could be four possibilities. The Government can correctly assess the underlying distribution as uniform or triangular. It can also misforcast the distribution as uniform when it is triangular or vice versa. The objective then is to find out if one distribution is better than the other when either distribution is equally likely. Can the demand condition influence the choice of appropriate distribution that would maximize the Government's expected gain?

### 1. Expected Gain

Recognizing that the risk associated with the choice of the pdf, the regulator needs a way to conduct comparative analysis. Rather than focus on the Government gain, a better measurement is the Government expected gain (EG). The EG is the value found by integrating the product of Government gain and the corresponding probability for all possible values of R. For example, let P(R) be the probability that the cost report is R. Then the Government's expected gain is given as:

$$EG = \int_L^H GG_R[p(R)]\,dr$$

where $GG_R$ denotes the Government's gain when the cost report is R.

## 2. Expected Gain Comparison

This analysis focused on risk reduction when choosing the pdf for use in the model. The primary objective was to determine under what demand conditions, if any, that one distribution should be preferred over the other. The choice of pdf was restricted to either the uniform or triangular distribution.

### *a. Methodology*

A linear demand curve of $Q=a-bP$ was used for computation. Six demand scenarios were considered in this context, with three scenarios based upon the choice of $a$ and three based upon the choice of $b$. Expected gains were computed for all four possible cases in each demand scenario. The results were listed in tables for comparison.

Table 3-1 compares High, Medium, and Low demand which corresponds to $a$=10, 6, and 5 respectively and a constant demand curve slope of $b$=1. Table 3-2 compares Steeper, Medium, and Flatter demand, which corresponds to $b$=0.5, 1, and 2 respectively, with a constant horizontal intercept $a$=10.

A base case was based upon the *Uniform* strategy when the demand is High, with $Q=10-P$, and the cost distribution is uniform, with its range *Very Narrow* between (4.9,5.1). All other entries in the payoff matrices are expressed as percentages of this base value.

### *b. Results*

Table 3-1 shows that a dominant strategy exists for a demand case with a *Very Narrow* and *Narrow* cost range. The *Triangular* pdf dominates regardless of the true state of nature. These cases are represented by the shaded cells in the table.

However, as the demand level declines in terms of *a* and the cost range widens, this dominance no longer holds. In these cases, the *Uniform* strategy performs best if the state of nature is in fact uniform. However, choosing the *Uniform* when the true state of nature is triangular, provides the worst expected payoff of the four possibilities. Given the true state of nature, the correct estimation increases the relative gains.

In Table 3-2 a dominant strategy clearly emerges. As the elasticity of demand decreases, or becomes steeper, the *Triangular* pdf performs best, whether the true state of nature

TABLE 3-1: PAYOFF MATRIX FOR THE GOVERNMENT AS A FUNCTION OF COST RANGE AND DEMAND LEVEL

| Demand Level[1] | Range[2] | Very Narrow | | Narrow | | Medium | | Wide | |
|---|---|---|---|---|---|---|---|---|---|
| | Strategy / Nature | Unif. | Tria. | Unif. | Tria. | Unif. | Tria. | Unif. | Tria. |
| High | Uniform | 100%[3] | 132% | 22.5% | 23.3% | 19.8% | 19.4% | 10.2% | 9.7% |
| | Triangular | 96% | 138% | 20.7% | 24.5% | 20.1% | 20.8% | 8.9% | 9.6% |
| Medium | Uniform | 3.9% | 3.8% | 1.0% | 0.92% | 1.7% | 1.4% | 2.6% | 2.1% |
| | Triangular | 3.8% | 4.0% | 0.62% | 0.77% | 0.81% | 0.87% | 1.1% | 1.2% |
| Low | Uniform | 0.15% | 0.13% | 0.14% | 0.13% | 0.51% | 0.43% | 1.1% | 0.96% |
| | Triangular | 0.05% | 0.06% | 0.03% | 0.05% | 0.15% | 0.18% | 0.36% | 0.43% |

1. Three demand levels are considered: High, Medium, Low demand corresponds to Q=10-P, Q=6-P,and Q=5-P respectively.
2. Four cost ranges are considered: *Very Narrow, Narrow, Medium, Wide*. These correspond to the ranges of (4.9,5.1), (4,6), (3,7), and (2,8) respectively. The apex point of the triangle distribution is set at five. The mean of the distribution, therefore, remains the same for both the uniform and triangle distributions.
3. This cell represents the base case, and each of the other cells in the payoff matrices is expressed as a percentage of this value. Specifically, the expected Government gain for this cell represents the result of the *Uniform* strategy when the demand is High with Q=10-P, and when the cost distribution is uniform with its range *Narrow* between (4,6).

Source: NPS Technical Paper, The Optimal Choice of Distributions in the Baron-Myerson Mechanism, forthcoming paper by K.L. Terasawa and D. Bearden.

is uniform or triangular. Again, the shaded cells represent the region where a dominant strategy exists.

Table 3-2 also shows the cost range to be an important factor. As the cost range narrows, the number of cases where the *Triangular* strategy dominates increases. For example, with the Medium elasticity cases the *Triangular* strategies are dominant when the cost range is *Very Narrow* or *Narrow*. Conversely, as the cost range becomes *Medium* or *Wide* with the Medium elasticity case, there is no dominant strategy.

### *c. Conclusion*

The payoff matrices indicate that there is no one overall dominant strategy when choosing between the *Triangular* or *Uniform* pdf. However there are demand circumstances where the *Triangular* strategy becomes dominant. These situations are typified by a combination of High demand, Low elasticity, and a *Narrow* or *Very Narrow* cost range.

TABLE 3-2: PAYOFF MATRIX FOR THE GOVERNMENT AS A FUNCTION OF COST RANGE AND DEMAND ELASTICITY[1]

| Demand Elasticity[2] | Range[3] | Very Narrow | | Narrow | | Medium | | Wide | |
|---|---|---|---|---|---|---|---|---|---|
| | Strategy / Nature | Unif. | Tria. | Unif. | Tria. | Unif. | Tria. | Unif. | Tria. |
| High | Uniform | 0.31% | 0.27% | 1.2% | 1.0% | 2.4% | 2.1% | 1.2% | 1.0% |
| | Triang. | 0.01% | 0.12% | 0.40% | 0.49% | 0.81% | 0.98% | 0.33% | 0.41% |
| Medium | Uniform | 52.3% | 68.7% | 25.9% | 28.7% | 16.7% | 16.3% | 10.2% | 9.7% |
| | Triang. | 47.9% | 70% | 25.9% | 30.6% | 16.7% | 17.3% | 8.9% | 9.7% |
| Low | Uniform | 216% | 348% | 103% | 164% | 77.3% | 95% | 49% | 51.6% |
| | Triang. | 197% | 349% | 104% | 165% | 74% | 99% | 47% | 55% |

1. Each cell in the matrix represents the relative gains using the base case discussed in table 3-1.
2. Three demand elasticity levels are considered: High, Medium, Low which correspond to Q=10-0.5P, Q=10-p, and Q=10-2P repectively. for a given level of price, the demand elasticity becomes higher as b decreases in a linear demand curve: i.e.

$$dn/db = \frac{-aP}{(a-bP)} < 0$$

3. The same three cost ranges used in Table 3-1 are used again here. Again the apex point of the triangle distribution is set at five. The mean of the distribution, therefore, remains the same for both the uniform and triangle distributions.

# IV. IMPLICATIONS OF USING THE MODEL IN DOD PROCUREMENT

## A. INTRODUCTION

In Chapter II, the researcher communicated that an important part of acquisition reform is the movement toward a price-based procurement system. Chapter III introduced the Baron-Myerson model and demonstrated its underlying principles for regulating a monopolist, or sole source supplier. If this model could be used in DOD procurement, it could offer many positive benefits.

While adoption of this model by DOD offers potential rewards, it is by no means a panacea for all types of sole source situations. Certain conditions must exist for the model to be implemented with favorable results.

This chapter discusses some of these conditions that must be met for the model to work. It also identifies and discusses potential concerns about using the model in the current DOD procurement environment.

## B. MODEL IMPERATIVES

It is important to emphasize that the model is not feasible for all situations or under all conditions. Certain critical criteria must be evaluated to ensure successful initiation of the Baron-Myerson model.

### 1. Non-Inelastic Demand

The dynamics of the truth-telling strategy of the Baron-Myerson model center around the premise that the regulator will determine the quantity to buy based upon the producer's reported cost. Therefore, the demand must not be totally inelastic to the price changes. Instead of a single rigid number, the buyer must have a range of acceptable purchase quantities.

### 2. Regulator Credibility

It is essential that the Government maintain credibility in the eyes of the producer for the model to work. There is a certain amount of gamesmanship occurring among the participants. The Government's promise to reduce or increase the number of items it will buy, based upon the producer's reported cost, is the key element that "forces" the contractor to tell the truth. Therefore, if the contractor feels the Government cannot follow through with its promise, he will behave quite differently from the Baron-Myerson predictions.

The Government must build its credibility through steadfast and consistent behavior. This means faithfully buying the purchase quantities specified by the rules of the model; or maybe not buying any items if the reported cost is too high. This may be difficult to do, but is necessary if producers are to believe the Government is serious.

## C. DEMAND IN THE DOD PROCUREMENT ENVIRONMENT

There is concern that the demand for the items DOD buys is very inelastic. In some cases this may be true. However, there is evidence to suggest that the demand is not always as inflexible as many would think. The numbers of systems to buy are generated through a complex process that is based upon detailed analysis. Yet, the process is very political and analysis does not always determine the final numbers.

### 1. Analytical Base

The demand for systems in the services are threat based and budget constrained. Limited resources force decision makers to choose between numerous force structure options in an attempt to obtain utility maximizing combinations. Structured analysis is conducted at many levels to provide decision makers with empirical basis for determining service requirements. A cursory overview of the process used by the Army is given here as an example.

The Army uses Total Army Analysis (TAA) to prepare its budget request for the two year budget cycle. The Training and Doctrine Command (TRADOC) has its TRADOC Analysis Command (TRAC) and Combined Arms Center (CAC) conduct analysis of future force structure needs. The numbers generated by TRADOC go to the office of the Assistant Deputy Chief of Staff of Operations for Force Development (ADCSOPS(FD)).

There, the ADCSOPS(FD) personnel conduct mission area analysis to balance the force structure requirements, costs, and combat payoffs of the systems and further refine the numbers. By conducting this trade-off analysis, the mission area personnel determine what they feel is required in the way of numbers of systems by type. These systems requirements are put in order of priority in hopes that the numbers can be achieved.

The priority list with its numbers is further reviewed by the office of the Assistant Secretary of the Army for Research, Development and Acquisition (ASARDA). Here more scrutiny is given to the numbers based on budgetary concerns and business factors. Economic order quantities[5], economic sustainment rates, and defense industrial base considerations are balanced with the yearly flow of funds in current and out years.

Afterwards, final decisions are made and numbers are submitted up the decision chain for approval and ultimate inclusion into the Program Objectives Memorandum (POM). Along the way, the CINCS, Chief of Staff, and Office of the Secretary of Defense provide input requiring reconsideration of the numbers.

The process described above is not carried out in isolation. The Deputy to the ADCSOPS(FD), COL Hixon, pointed

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[5]In fact, the existence and analysis of economic order quantities imply the tradeoff between quantities and price.

out that many destabilizing factors influence the requirements for programs on a day to day basis. The growth of technology creates an industrial mismatch. The shrinking budget produces far reaching turbulence. Programs run into problems that cause cost overruns and schedule delays. There are minimum economic sustainment rates and sustainment of the industrial base to consider.

These elements in the acquisition environment force decision makers to change the numbers demanded many times a day. There is no analytical tool that can handle all of these factors at once in an easy fashion. COL Hixon said that these daily revisions "must be mixed in with a dose of common sense." [Ref. 15]

These observations seem to indicate that the demand is indeed elastic. Even when a target quantity is chosen in conjunction with the target price, the quantity often changes with the changes in the circumstance. Previous decisions are often rendered ineffective by many rapidly changing externalities; and adjustments in quantities are frequently made based on price changes.

**2. Political Influence**

Little mention has been made so far of the political forces and their impact on the demand generation process. The acquisition arena is full of political influences, both inside and outside of DOD. These factional threats force program

sponsors to be very resolute in defending their claimed program requirements.

Having many competing technologies maturing at the same time and the goal of fielding them as soon as possible, means fierce competition for shrinking procurement funds. Presently, DOD cannot fund all of the systems in development with the amount of money allocated in the defense budget. The fight for funds has bred a culture inside of DOD that forces program advocates to staunchly defend the number of systems they declare they need. As Richard Doyle, budget professor at the Naval Post Graduate School and former Congressional staffer said,

> no one is going to say they don't need all of the systems they requested earlier, because they know the money will be taken away and given to somebody else. [Ref. 16]

This sentiment was shared by a ranking source from the office of the Navy Comptroller. The source mentioned that the Navy no longer wanted the original number of a certain type of system it was scheduled to buy. Instead it wanted a larger number of another type of system. A conscious decision was made not to inform the Congress for fear that the Navy would lose the money for the systems they would give up and would not receive it back to buy more of the desired systems.

This attitude of hold on to what you have, instead of what might be best, is pervasive. It is a major reason that

program sponsors refuse to admit that their program number is not capable of going lower. Yet, amidst all the cries that the demand is unmovable, program numbers are reduced almost daily, as the budget drops or priorities change. The Army Paladin is a prime example. Its original number started at 1,700 units. This was reduced to 1,360 units, then to 1,138 units, and eventually to 824 units. [Ref. 17]

Even the existence of reduction contingency plans is a closely guarded secret. When the Navy source was asked if a certain program would be cut if further funding reductions occurred, he replied that, "...we all know *that* (decrements) list does not exist until the cuts are actually made."

A former member of the ADCSOPS(FD), and primary player in the demand decision for the Paladin system, said that it was a closely kept secret that a plan existed to vary the final number of units bought. Decision makers were going to base the final quantity upon the price reported by the producer. Although the official number was 824 units, the minimum number acceptable was 815 units. If the price was good, the number could increase up to 835 units, then to 862 units; with the maximum being 906 units.

The source also volunteered that the number really wanted was 835 units, but 824 units was chosen because it was the most "defensible". [Ref. 18] This seems to be another important corollary of the political influence on the process. The number chosen as the demand must be justifiable

to the many adversaries looking for a way to get money from the program. The threat is not only from Congress or other services. The threat can come from sponsors of other programs within the same service.

## D. CONTRACT TYPES FOR USE WITH THE MODEL

Given the imperatives listed previously, it is reasonable to assume that certain contract types are better candidates for using the model than others.

### 1. Cost Type Contracts

The Baron-Myerson model may not be well suited to contract situations that normally dictate the use of cost type contracts. Contracts for procurement of immature technologies or RDT&E contracts are two such situations. Under RDT&E contracts, only limited numbers of prototype items are produced. It is difficult to vary the demand and make use of the Baron-Myerson model.

Another reason is that the contractor may not have a firm or reasonable estimate of the actual cost of producing a developmental item or an item with immature technology. The contractor's reported cost to the regulator could be significantly wrong. This prompts the contractor to pad its cost estimate to avoid excessive risk under the Baron-Myerson model and reduces the potential efficiency gain for the Government.

Although the model may be more difficult to use for development contracts, its use in the follow-on production contract may be a more effective cost reduction incentive than those presently used. Assuming that a sole source product developer will receive the production contract, early introduction of the model will give the contractor strong incentive to design in cost saving features.

### *a. Present Cost Reduction Incentives*

Present incentives for developmental cost reductions are not necessarily very effective. Government contract officers usually assume the contractor is profit motivated. Therefore, incentives typically take the form of award fees or incentive fees. This system may not always be effective in accomplishing cost reductions if contractors look ahead to the future profitability of the production contract.

Companies typically expect to make the largest share of their profit on the follow-on production contract. Profit in production contracts is generally figured as a percentage of the cost to build the item. As a result, a sole source contractor's best option during development might actually be to drive the cost of an item up to get a higher total profit later in the production contract. [Ref. 19]

### *b. Baron-Myerson As An Incentive*

Under Baron-Myerson, both the quantity bought and the producer's profit become larger as the cost decreases. Therefore, it is in the developer's best interest to design in low cost producibility and have the Government buy more items.

### 2. Fixed Price Contracts

The Baron-Myerson model is best suited to procurement situations that normally support the use of fixed price type contracts because the producer is better aware of his production cost. Thus, the Government can be more confident that the producer's reported cost estimate will be reasonably accurate.

There are incentives for the Government to use the model instead of a typical fixed price contract. Contracting officers can currently use market or catalog price to determine reasonableness of producer price when the item is sold in sufficient quantities to the public. Remembering the naive approach, the price charged by a sole source supplier is set to maximize profits and is not regulated by competition. Thus, the price may be excessively high, even though it is a catalog price. Exercising a model like Baron-Myerson to regulate the price could produce substantial savings for the Government.

## E. POTENTIAL AREAS FOR USE OF THE MODEL

The following section identifies a few examples that might support using the Baron-Myerson technique.

### 1. Major Weapons Systems

The Baron-Myerson model might not be the best option for administering a procurement for major weapon systems that have a high unit cost and strong force structure driven demand. However, the model should not be immediately ruled out as an option.

There is some flexibility built into the numbers of any system. While basic force structures tend to dictate a minimum number, areas for flexibility do exist. The number of items bought as war reserves, operational readiness floats, reserve cycle floats, depot floats, training base and POMCUS stocks are flexible to a degree.

### 2. POM Addendums

These go up to Congress each year as items that the services want but cannot afford. Sometimes Congress will decide to appropriate some funds towards the purchase of these items. One example was the Army's M992 Field Artillery Ammunition Support Vehicle (FAASV). The purchase was one where the demand was not critically high. In this case, the number bought was largely determined based upon the price of the item. [Ref. 18]

One aspect that helped remove the economic order quantity consideration from the decision was that the M992 was an adaption of the M109 already in production. Having a warm production line allowed additional flexibility since the cost of starting and stopping a new line for a small production run was not a factor. [Ref. 18]

### 3. Service Life Extensions Or Midlife Product Improvements

Often, the need to improve the entire fleet is not critical because an existing system is already performing the task; i.e. upgrading the electrical systems on the M1A1 heavy armored tank. In this case, the tank is performing satisfactorily with the current system. Upgrading it will not significantly increase combat power, but does result in a better system.

### 4. Congressionally Mandated Awards

Occasionally, Congress will mandate that a particular company will receive award of a contract without competition. One such case was the Army's purchase of the M16A2 from Colt Firearms. Here, there was a suitable weapon in the field already, so the rate of replacement was not a critical factor. This type of situation eliminates competition as a price regulating option. As a result, the model could be used to determine the quantity bought. Another example was the MARK 19 Automatic Grenade Launcher, which was awarded to a Japanese owned company, Sako, but built in Florida. [Ref. 18]

### 5. Others

Any items from a commercial sole source where the demand quantities are not rigidly set. The case of the state-of-the art encryption radios mentioned in chapter two is a good example.

Items that have a long shelf life and need not be ordered in specific quantities are also potential candidates. Inventory type items, ordered on a periodic basis may provide conditions necessary for use of the model. As an example, The PEO of armaments stated that the quantity of tank main gun rounds was not too difficult to change if money became a problem. [Ref. 20]

## F. SUMMARY

This chapter pointed out that the Baron-Myerson model is not applicable to all situations. Certain conditions must be satisfied for the model to work well. Notably, there must be some flexibility in the demand numbers, so that the regulator can stick to his promise to purchase the number of systems indicated by the model. Additionally, the regulator must maintain credibility in the eyes of the producer to induce him to report his costs truthfully.

While the demand in DOD is portrayed to be analytically based and very inflexible, the frequent changes to the numbers as a result of funding cuts, or due to political reasons, indicate that some flexibility does exist. Even with major

weapon systems there is a range of acceptable numbers to some extent. However, as the criticality of need for an item rises, the viability of using the model diminishes.

The model may not be well suited to cost type contracts due to uncertainty of costs, even on part of the producer. Yet, it could provide cost reduction incentives during development of systems. The real benefits of the model are best realized in a situation that would call for a fixed price type contract where the producer better knows his costs.

Finally, there seem to be areas where DOD could use the model. Some example cases were proposed to illustrate that possible uses for the model do exist.

# IV. CONCLUSIONS AND RECOMMENDATIONS

## A. CONCLUSIONS

The following are conclusions that apply to this research effort.

1. Potential benefits can be realized if DOD can adopt the Baron-Myerson model. Foremost, the model could offer a technique to maintain the public trust and protect taxpayer interests in a price-based procurement system under sole source conditions. Additionally, CAS and TINA requirements could be loosened, allowing commercial vendors with advanced proprietary technology easier access to the DOD marketplace. Reducing requirements would also mean less capital and personnel overhead burden for both the Government and vendor. Shortened acquisition cycle times are another possibility.

2. When the distribution options are uniform or triangular, the risk associated with choosing the underlying distribution can be reduced to some degree through comparative analysis. The expected gain matrices show that certain conditions exist under which use of the triangular distribution is conclusively better than use of the uniform distribution. In other situations, the comparison between the two distributions is not as conclusive. Having this method for comparing the EGs of the distributions under different

conditions allows the regulator to pick the most risk averse strategy with the information at hand.

3. Certain conditions must exist for the model to be implemented with favorable results. The Baron-Myerson model is not a "silver bullet" that is applicable to all situations. Specifically, the more critical the need for the item, the more inflexible is the demand and the less viable is the model.

Some example cases for possible use of the model were given in chapter four. This list is by no means comprehensive. Any situation where competition is restricted and the conditions already mentioned exist might benefit from the use of the model. The important thing is that the regulator know what these conditions are and recognize when they are present.

4. It appears that the demand in DOD is portrayed as being less inflexible than it truly is. The frequent reduction and second guessing of weapon system quantities, even after all of the analysis, casts doubt upon the contention that the numbers are immovable. Furthermore, the zero-sum culture created by the competition for funds tends to inject a kind of artificial zeal into the protection of the numbers of items requested. Finally, it presently seems as though having a justifiable or defensible number is more important than achieving efficiency in many cases. The Paladin case provides a good example.

## B. RECOMMENDATIONS

1. Continue to explore the use of the Baron-Myerson model in conjunction with acquisition reforms. If DOD is to use the model for procurement, further study of the impact that current legislation, such as the Competition In Contracting Act, Truth in Negotiations Act, and Cost Accounting Standards, has on the model must be carried out to integrate it into the process. This study must necessarily lead to modifications or waivers to existing legislation to allow the practitioners freedom to implement the model.

2. The Department Of Defense should look into conducting a pilot program on a small scale to observe the model in use. This would allow a low risk method to evaluate the model's potential for more widespread use. It would also provide a nucleus of trained personnel to help educate others on how to use this model.

## C. ANSWERS TO THE RESEARCH QUESTIONS

Q: Could the Baron-Myerson model be used in DOD procurement as a price regulating tool under a price-based procurement process?

A: The model should be studied in greater detail before this question can be answered emphatically. Yet, there do seem to be indicators that the model could work if applied selectively and under the correct conditions. And, it does seem as though the necessary conditions for the model's use

exist on some scale in DOD. There are, however, many barriers to its use in the current system, to include present statutes and deeply ingrained cultural norms. It will take a great effort to build a coalition large or powerful enough to push an idea like this through the system. Even so, the potential benefits offered by this model warrant additional effort in this direction.

Q: What conditions or parameters determine the best distribution to use between the uniform or triangular distribution?

A: There was no overall best strategy for risk reduction when choosing the pdf. However, when the cost range is narrow, the demand level high, and the demand curve steeper, or less elastic, the triangular distribution tends to dominate regardless of the true underlying distribution. When these conditions do not exist with one another, then there is usually no dominant strategy.

Q: What conditions are necessary for best use of the model?

A: The model will work best when two primary conditions are satisfied:

- The demand for an item is not inflexible;
- The characteristics of the item are such that the producer can accurately estimate his opportunity cost of making the item.

Q: Do favorable conditions exist in the DOD procurement system for use of the Baron-Myerson model?

A: Given the decrease in size of the defense industry base and the resulting reduction in competition in some areas, there seems to be enough potential benefit for DOD to consider using the model. It does appear that the demand for some if not many items purchased by DOD is not as rigidly set as many would suggest. While the model is not best for all situations, there are cases that meet the necessary conditions to use the model.

## D. SUGGESTIONS FOR FURTHER RESEARCH

Areas that merit further research follow.

1. The use of other distributions can be studied to provide additional options besides the uniform and triangular distributions.

2. Analysis of the model under conditions of repetitive buys and their effect on contractor behavior warrants further study. Contractors may react differently to the Government's demand curve if he has motives other than profit in the near term. These might include maintaining a warm production line or seeking to optimize his use of production capacity over time.

3. Further work can be done on conducting a sensitivity analysis for the regulator's cost estimate. The regulator's modified demand curve is a function of its estimate of the

producer's opportunity cost of the item. Thus, a sensitivity analysis would be useful in determining the cost/benefit of obtaining additional information.

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